High power-density motors enable rigs to drill more efficiently

A motor with higher power density can deliver more power with comparable weight or, similarly, comparable power at a reduced weight or size.

Alder H. Crocker and Dan Cook, Ward Leonard

For more than 50 years drilling rigs have been using modified locomotive traction motors for top drive, rotary table, mud pump and drawworks use. These large and heavy motors were first installed as an iterative solution to provide more power to drill the hole than the then-standard smaller, less powerful motors—and as a stop-gap to the intensive task of engineering new motors specifically tailored to achieve peak efficiency for each application.

However, as demand continues to increase for companies to develop solutions that reduce total operating costs while still being able to push rigs to drill deeper, faster and more efficiently—especially in the current market—it is more apparent that new motor technologies need to be at the front line of innovation for companies to achieve their individual strategic and operational goals.

Next generation of drilling motors

Ward Leonard has optimized four distinct but integrated areas that have an immediate impact on improving performance and productivity: motor size, weight, horsepower and torque.

The result is the industry's first line of high power-density AC-induction motors that use advanced thermodynamics and applied physics to deliver up to 50% more power and torque within the exact same motor frame size that is currently standard for each application.

The motors range from 450 hp to 2,000 hp; are purpose-built for top drives, mud pumps, drawworks and rotary tables; and feature proprietary intra-slot cooling technologies and fully optimized copper-to-steel ratios to achieve high-performance capabilities.

With high power-density motors, rig builders, drilling contractors and systems integrators are now able to develop the innovative rig and application designs they envision to drive the industry to greater efficiency.

	"Standard" 400-hp Motor	High Power-Density 600-hp Motor
Dimensions [W x D x H]	**19.6 in. x 19.8 in. x 47.9 in.**	
Weight [lbs]	2,800	2,800
Rated Power [hp]	400	600
Torque [lbf-ft]	1,795	2,685
Current [Arms]	350	470
Speed [RPM]	1,172	1,163
Voltage [Vrms]	575	575
Frequency [Hz]	40	40
Volume-Power Density [hp/ft]	37.2	55.8
Mass-Power Density [hp/ton]	286	428

This table shows the comparison between a standard motor and a high power-density top drive motor. *(Source: Ward Leonard)*

High power density defined

As it relates to electric drilling motors, power densitycan be defined as the ratio that describes the total rated power of the motor relative to its weight (power-to-weight). A higher power density, therefore, enables a motor to deliver more power with comparable weight or comparable power at a reduced weight.

Another form of power density can be defined as the ratio of total rated power of the motor relative to the volumetric footprint required (power-to-size). Again, a higher power-density motor can therefore deliver more power at a comparable size or comparable power at a reduced size.

Ward Leonard's solutions use both principles to enable users to achieve peak power performance and greater cost efficiencies throughout their operations.

Top drives

The advantages of high power-density top drive motors can be significant. Because the primary duty of the top drive is to spin the pipe while drilling, the depth of

The WL12BB060 top drive motor delivers up to 600 hp in a 400-hp standard 'square-style' frame and is 1,200 lb lighter than a standard 600-hp drilling motor. *(Source: Ward Leonard)*

the hole is therefore limited by how far the pipe can go and keep spinning. To keep the pipe spinning at greater depths, higher torque is required to overcome the friction of the hole wall.

For directional (horizontal) drilling, the pipe must both spin and bend at the same time. Higher torque provides the power to keep the drill from getting bound up. With Ward Leonard top drive motors that deliver up to 50% more torque and horsepower, operators now have the ability to:

- Grind through more difficult geologies;
- Overcome friction in the hole wall at greater depths;
- Jog the pipe faster and with more power when a pipe bind occurs;
- Make longer horizontal runs;
- Drill and complete deeper holes faster; and
- Thread larger diameter pipes—and therefore drill larger holes—without changing rig tonnage or top drive apparatus, motor, drives and other associated equipment.

The company offers five motors for top drive applications ranging from 450 hp to 1,350 hp. Its WL12BB060 "square-style" motor delivers up to 50% more horsepower and 50% more torque than standard 400-hp frame motors (600-hp and 2,725 torque lb/ft), and weighs 1,200 lb less than a standard 600-hp frame motor.

Mud pump, drawworks

Fundamentally, the faster a hole can be drilled and completed, the faster it will become an income-producing well. Mud flow capacity is critical as it impacts the speed the drillhead can spin, and the pressure of the mud itself directly impacts the bite of the drillbit—both of which come from the amount of torque delivered by the mud pump motor. With high torque and horsepower motors, operators can expect:

- More mud flow capacity and mud pressure;
- Faster drillhead spin rates;
- Drillbits that bite more;
- Ability to drill through consistent formations at faster speeds and tougher formations at the same-as-current speed;
- Elimination of the need to swap out mud pump sleeves to accommodate higher pressures at the same flow; and
- Faster completions, which means fewer total drilling days.

As it relates to drawworks, the space a typical unit takes up is critically important. More space occupied equates to more overall cost. With compact high-horsepower high-torque motors, operators can improve productivity without increasing size or weight, apply more power and torque to the drillstring, pull up the pipe faster from greater depths, overcome intense friction and massive weight, increase overall performance and productivity, and complete wells faster and reduce total drilling days.

Ward Leonard offers multiple high power-density motor options for mud pump and drawworks applications—ranging from 1,350 hp to 2,000 hp. Its 2,000-hp (WL29BC200) motor delivers 33% more horsepower than identical-sized 1,500-hp motors and is 14% smaller and 10% lighter than similar 2,000-hp motors.

Changing economics of drilling

Similar to Moore's Law, the power required for drilling motors will continue to increase because there are formations operators currently can't drill into with today's technology or won't because it isn't cost-effective enough.

High power-density drilling motors take operators to the next level. Not only do they essentially "super charge" the capabilities of each application and their position in the value chain; they usher in a new lens for analyzing overall economics.

The benefits of using these compact lighter higher horsepower and torque motors can result in deeper, faster and more efficient drilling with less downtime; less days to drill and complete; fewer motor burnouts due to enhanced cooling properties; reduced maintenance, repairs and spares costs; greater portability moving from site to site; reduced transportation costs and road weight fees; more flexible skid arrangement and reduced potential for wide and heavy loads; easily retrofitting existing applications without changing equipment designs; and greater flexibility to develop innovative rig designs that will themselves improve performance and productivity. EP